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Method and arrangement for determining the operating frequencies of base stations of an internal network

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B1 FIELD OF THE INVENTION

The invention relates to redetermining the operating frequencies of base stations of a cellular radio network installed indoors, when the operating conditions of the internal network have changed from the previous situation.

Here an internal network means a cellular radio network or a part of a cellular radio network implemented indoors or in an otherwise restricted area. Here an external network means another cellular radio network or a part of a cellular radio network detected in the area of the internal network.

a BACKGROUND OF THE INVENTION

A problem with the known solutions is the fact that measurements have to be carried out again when changes have taken place in the operating frequencies of the base stations in the environment. This change causes a change of the spurious frequencies in the internal network, which may cause a deterioration in the quality of the connections of the internal network.

In addition, the need for a measuring device with sufficiently high capacity for performing a quick and accurate frequency scanning, due to the width of the frequency band to be measured, is a problem with the prior art solutions.

A known prior art publication number EP 0 716 555 A2 exists in which each base station of a cellular radio system performs repeated measurements on interference levels and selects into use such channels where the level of measured interference is low. Another known prior art publication number US 5,475,869 introduces an arrangement where also measurements describing interference from external networks are taken into account during channel allocation.

a SUMMARY OF THE INVENTION

It is an objective of the invention to present a new, more advantageous solution for determining the operating frequencies of the base stations of the internal network and a method, which enables redetermination of the frequencies of the internal network without a new measurement of the interference level.

The invention relates to a method for redetermining the operating frequencies of the base stations of an internal network, when the operating conditions of the internal network have changed. The characteristic features of the method according to the

invention are recited in the characterising portion of the independent claim directed to a method.

Here a change in the operating conditions of the internal network means at least an increase or decrease of base stations of the external network, changing of the operating frequencies and/or transmission powers and a change in the propagation of radiowaves caused by external conditions.

The invention also relates to an arrangement for redetermining the operating frequencies of the base stations of an internal network, which have earlier been determined by frequency measurement, when the operating conditions of the internal network have changed. The characteristic features of the arrangement according to the invention are recited in the characterising portion of the independent claim directed to an arrangement.

A special device for measuring interfering frequencies in order to find suitable frequencies inside a building according to a secret patent application FI 981491 (Configuration method for a base station) of the same applicant is preferably used in the frequency measurement. The device is used to measure the intensity of the interference level at the frequencies used by the cellular network. The device is moved in the building in the desired area of the internal network for finding free frequencies. On the basis of the measurement, operating frequencies with a lower interference level than the required field strength are charted for the base stations.

The spurious frequency spectrum is measured once in the area of the internal network, e.g. inside a building, plant area etc. for finding the frequency restrictions caused by the radio transmission of the external network to the internal network. The measurement data are transferred from the measuring device preferably by a data call to the Network Management System (NMS). The measuring device is then preferably a special mobile station adapted for use in measurements. At first, the frequencies of the base stations of the internal network are selected on the basis of the measurement. The external network may later start interfering with the internal network strongly, if a frequency already being used in the internal network is taken into use in a base station of the external network near the internal network. According to the invention, the original measurement and the frequency plans of the external network are used in the new planning of the frequencies of the internal network. Thus the area of the internal network need not be visited again for a new measurement.

The method functions especially well if it has been possible to measure and save during the measurement the cell information of radio transmissions of external cells that can be heard in the area of the internal network. If one of the frequencies being used in the internal network is given to a cell of the external network detected in the measurement, it is known for certain that the frequency of the base station of the internal network must be changed.

In addition, the frequencies selected for the use of the internal network can be checked after the selection by the measurement of the reception level and the Carrier/Interference ratio. This is preferably performed by a measuring device according to the invention.

~~Preferred embodiments of the invention are set forth in the dependent claims.~~

In the following, the invention will be described in greater detail with reference to the accompanying drawing, in which

Figure 1 is a flow chart of a method according to a preferred embodiment of the invention for selecting the operating frequencies of the internal network,

Figure 2 is a block diagram of an arrangement according to a preferred embodiment of the invention,

Figure 3 shows an example of a measurement route for measuring the interfering frequencies,

Figure 4 shows a saving form of the measurement results according to a preferred embodiment of the invention, and

Figure 5 is a flow chart of a method according to a preferred embodiment of the invention for finding the most suitable operating frequencies of the internal network.

Figures 1A and 1B show a divided flow chart of a method according to the invention for changing earlier determined operating frequencies of the internal network on the basis of the operating frequencies of the base stations of the external network and earlier measurement information.

Figure 1A illustrates the following. In the network control system, the results of the earlier measurement of the interfering frequency spectrum are preferably saved as grouped according to the base stations of the internal network 1.

It is examined with the network control system if there are changes in the external network 2, which have not been handled with regard to the internal network. If there are changes that have not been handled, it is examined if the frequency used in the internal network has been taken into use in the external network 3. If the frequency taken into use in the base station of the external network is not in use in the internal network, the process returns to step 2 to examine if there are still changes of the external network, which have not yet been handled. Correspondingly, if it is found out in step 3 that the frequency taken into use in a base station of the external network is in use in the internal network, the process moves to examine if the base station being changed is the new base station installed now 4, which did not exist earlier in the surrounding cellular radio network. If the base station is new and possibly at an interfering distance, which can be discovered when the radio network is being planned, as a precaution the base station of the internal network, the frequency of which is used by the new base station of the external network, is changed to an interference-free frequency on the basis of an earlier measurement and changes of the external network 6. If the base station of the external network is not new and interferes with the internal network on the basis of an earlier measurement 5, the base station of the internal network, the frequency of which is used by a base station of the external network, is changed to an interference-free frequency on the basis of an earlier measurement and changes of the external network 6. If the base station of the external network is not new and has not been interfering before, the process returns to step 2 to examine if there are still changes of the external network left, which have not been handled yet. If there are no unhandled changes of the external network left 2, the process is stopped. It is clear to a person skilled in the art that in steps 3 to 5 of the method described above it is generally examined if a frequency used in a base station of the internal network has been taken into use in the external network, as a result of which an interference-free frequency is changed to the base station of the internal network on the basis of the earlier measurement and the frequencies of the external network, when required.

From Fig. 1B it is seen how an interference-free frequency or a frequency which was originally interference-free and which has not been abandoned in the internal network because of frequency changes of the external network is selected on the basis of an earlier measurement and changes of the external network. In the first step, a first frequency is selected from the frequency range reserved for the internal network 7, which first frequency is not being used by such a base station of the internal network, which could cause interference to the base station for which a new interference-free frequency is being selected. In the next step it is examined if the

frequency was interference-free on the basis of an earlier measurement 8. If the frequency is interference-free on the basis of the measurement, it is examined if the frequency has remained interference-free from the changes of the external network 9, and if it has, the selected frequency is taken into use 10. If the frequency was not interference-free in the measurement, it can be examined if the frequency has become interference-free from the changes of the external network 11 and it can be

taken into use 10. If an earlier interference-free frequency has not remained such or a frequency which had interference earlier has not become interference-free, the next frequency, which is not being used by such a base station of the internal network, which could cause interference to the base station for which a new interference-free frequency is being selected, is selected from the frequency range of the internal network 12.

Fig. 2 is a block diagram of an arrangement according to the invention for redetermining the operating frequencies of base stations of the internal network, which have earlier been determined by frequency measurement, when the operating frequency of the base stations of the external network has been changed. The arrangement comprises a processor unit 13, which includes at least a processor A, a oscillator B for stepping the processor and a memory C, a display device 14, a data input device, such as a keyboard 15, a first database 16 for saving the measurement data of an earlier measurement and a second database 17 for saving the operating frequencies of the base stations of the external network. The processor 13 determines the new operating frequencies of the base stations of the internal network on the basis of input data, such as commands given from the keyboard 15, the information of the first database 16 and the second database 17 according to the flow charts of Figures 1A, 1B, for example.

The databases 16, 17 can also be saved in a separate storage element, such as the database of the control system of the mobile communication network. The operational blocks 13, 14, 15, 16, 17 shown in Fig. 2 can be placed alternatively in one or more separate computer devices. Suitable computer devices are a portable computer and a mobile station with multiple functions, for example.

Fig. 3 shows a map of a measuring route for measuring the interference levels indoors. A base station 19 of an internal network is situated in a room 18. The measurement is performed by circulating the base station 19 in the room 18, for example, along a route shown by the broken line 20, which goes to the corners of the room 18 and also close to the base station 19 in order to perform the interference measurement as comprehensively as possible.

Fig. 4 shows, by way of example, a saving form of measurement results, which contains the following information: frequency and interference level and if possible, the Base Station Identification Code (BSIC) and Base Transceiver Station Identification (BTS_ID) of the base station of the external network, which produces the radio transmission. The base station identification code typically consists of the

colour codes of the general mobile communication network and the base station. The base transceiver station identification typically consists of the following parts: the Mobile Country Code (MCC), the Mobile Network Code (MNC), the Location Area Code (LAC) and the base station code.

Fig. 5 shows a flow chart of a method according to the invention for finding the most suitable operating frequencies of the internal network with regard to one frequency to be examined. In step 22, the signal strengths (Rx Level) received are measured, while the base station of the internal network transmits a signal on a Broadcast Control Channel (BCCH) selected for the test on the same measurement route as above in Fig. 3, for example. The measurement is performed both on the broadcast control channel selected for the test and all the frequencies to be compared. This provides the information whether the transmission of the broadcast control channel is heard in the area of the internal network and whether the interference is heard in the frequencies to be compared. Of the measurement samples of the signal strength of the broadcast control channel, 90% have to be higher than the minimum value set in advance, step 23. This minimum value is preferably -77 dBm. Because the propagation of the radiowaves in the frequencies used in the system is practically the same, the measurement of the signal strength performed on the selected frequency is also valid at other possible operating frequencies. Here a possible operating frequency means a frequency which was found to be valid in an earlier interference measurement. If the criterion of the signal strength is not met, the audibility is not sufficient but weak, step 24.

When the criterion of the signal strength is met, the Carrier/Interference (C/I) ratio is also calculated in step 25 on the measurement route for all possible operating frequencies by using the samples of the signal strength of the broadcast control channel measured earlier and an interference measurement carried out on the frequencies to be compared. An estimate of the C/I ratio is obtained here by dividing the signal strength received on the broadcast control channel by a signal strength received at the frequency to be compared. Due to the structure of the cellular network, all the frequencies include some signal strength, which is received from other parts of the cellular network. However, the frequency used in the broadcast control channel during the measurement cannot be compared to spurious transmissions on the same channel. In step 26 it is examined whether the C/I ratio is sufficient in all the samples. The sample-specific minimum value of the C/I ratio is preferably 12 dB. If the criterion is not met, the frequency has too much interference, step 27.

In addition to this, the suitability of the channel is estimated by measuring the strength of the adjacent channels so that in addition to measuring if the limit of the C/I ratio, 12 dB, has been reached, the strength of the adjacent channels is also measured for all the samples. The strength must not exceed by more than a certain limit in either channel the signal strength of the broadcast control channel, on which a signal is transmitted for measurement, step 28. The adjacent channel is generally allowed by be stronger by 9 dB at the most, because then the channels can be separated with the frequency accuracy of transmission and reception. If there is a stronger radio transmission on the adjacent channel, it is heard on the actual channel in spite of the channel separation 29. When all the criteria examined in steps 23, 26, 28, are met, the frequency is suitable 30.

At the end of all the measures, the measurement data are saved in a special file e.g. in the following manner.

BCCH	BSIC	C/I limit	Audibility limit	90% audibility limit
52	2	12 dB	-87 dBm	-77 dBm
			Portion exceeding the limit	Portion exceeding the limit
			100%	100%

Table 1

Table 1 shows the number 52 of the broadcast control channel (BCCH) used for transmission and the base station identification code (BSIC) 2, the limit of an acceptable C/I ratio, 12 dB, absolute audibility limit -87 dBm, the audibility limit -77 dBm required of 90% of the samples, and next the relative proportions that exceed the audibility limits, here 100%.

BCCH	BSIC	Average C/I	Acceptable samples
74	2	3.5 dB	17.4%
76	2	9.1 dB	34.8%
68	4	15.8 dB	60.9%
49	5	17.0 dB	63.0%
25	2	23.7 dB	76.1%
65	1	30.7 dB	82.6%
30	1	30.5 dB	82.6%
39	6	28.9 dB	84.8%
72	3	27.0 dB	87.0%
26	3	34.7 dB	91.3%
62	5	33.2 dB	95.6%
35	5	49.5 dB	97.8%
41	5	40.7 dB	97.8%
21	5	40.7 dB	100.0%
51	3	21.9 dB	100.0%
46	1	34.7 dB	100.0%
36	5	43.5 dB	100.0%

Table 2

Table 2 shows the number of the channel (BCCH) being listened to and the Base Station Identification Code (BSIC), average C/I ratio and a portion of samples of the measurement acceptable for the interference limit, in which C/I > 12 dB.

The table can also be complemented by a column to indicate the interference caused by adjacent channels to each channel. Advantageously it can also indicate which channel causes interference to a certain channel.

The table is also used to establish the order of suitability of the operating frequencies.

Let us discuss as an example the addition of a base station to the external network and the introduction of a new frequency in the new base station to be added. For the internal network the frequency spectrum is measured at first, whereby at least the interference levels at different frequencies of the frequency range are determined, but also the identifier of the cell transmitting the signal, if the identifier can be received correctly. Later, the base station is added to the external network and a new frequency plan is loaded. The old and the new frequency plan are used together

with the measurement data of the frequency spectrum to establish whether a frequency used by the internal network has been taken into use in a base station of an external cell in the vicinity, whereby a new frequency has to be changed for the base station of the internal network. The frequency is selected from a table formed on the basis of the frequency plans of the external network and the frequency spectrum measured before the change. However, it is not always possible to know for certain from which base station the earlier interference came, especially if the identification information of the cells corresponding to the interference are not available. However, the base station which is the most likely to produce a certain radio transmission can be concluded on the basis of a chart of the external network, if a chart indicating the location of the base stations is available.

It should also be noted that the measurement of the frequency spectrum of the area of the internal network can be limited to the frequency range used by the internal network, and the frequency range used by the whole system need not be measured. Measurement can be done quicker because of this. The measuring device can be a mobile station equipped with special programs, for example.

In this connection, an interfering transmission means a radio signal transmitted by a base station of the external network, which is audible in the area of the internal network.

The invention is not limited merely to the above examples of application, but many modifications thereof are possible within the scope of the inventive idea defined by the attached claims. Especially it is to be noted that the invention can also be applied in other systems than the GSM system mentioned above. An example of other systems is the Universal Mobile Telecommunications System (UMTS).